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High Performance Computing for CAE simulation

Bosung Lee

CPO (Chief Product Officer)

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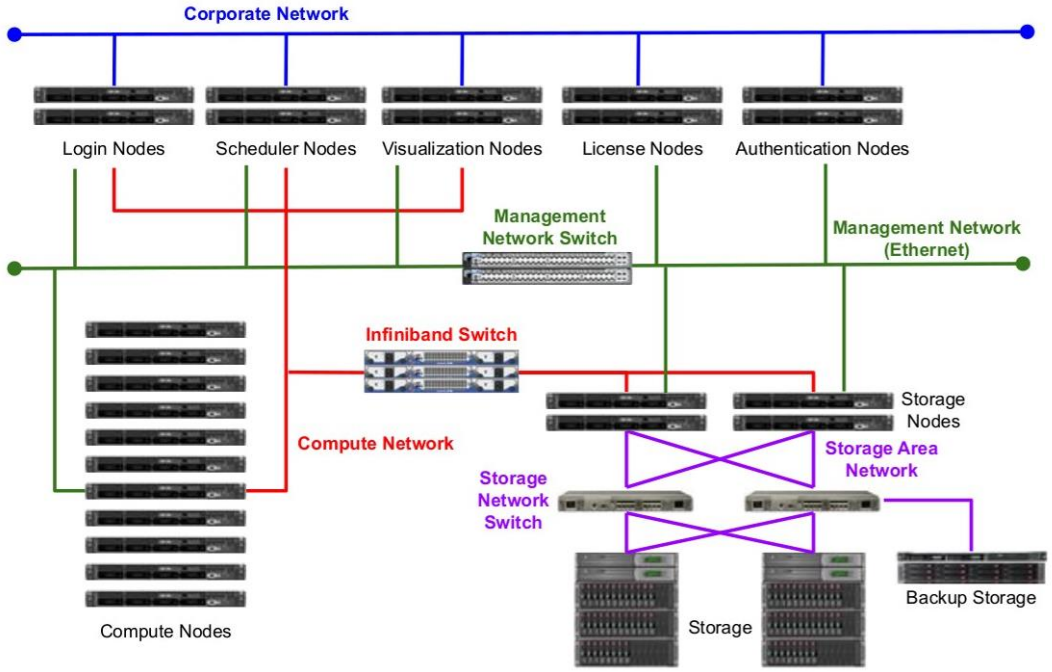
Need for high performance computing in CAE simulation

- **Massive computational resources**
  - Parallel processing speeds up calculations significantly by enhanced computational power
- **Handling larger data sets and intricate geometries**
  - Manages more parameters for advanced modeling and increased simulation complexity
- **Simulates finer details for improved accuracy and resolution**
  - Crucial for predicting real-world behaviors in simulations
- **Accelerates multiple iterations within shorter timeframes to reduce time to solution**
  - Enables quicker design decisions and model refinement.
- **Scalability and flexibility for growing computational requirements**
  - Adapts to varying project demands, from small tasks to large simulations.
- **Enabling Advanced Algorithms to support complex solvers and algorithms**
  - Allows for advanced methods like multi-scale modeling and machine learning

On-premise HPC architecture and simulation workflow



- User / Management Server
  - Login nodes : user login & jub submission
  - Scheduler nodes : scheduling HPC jobs (LSF / PBS / Slurm)
  - Visualization nodes : pre & post processing with GPGPU
  - License & Authentication nodes : manage licenses and user auth
- Compute nodes with high performance processors and memory
- Management network to manage and monitor the HPC
- Compute network to handle MPI & File I/O communication
- Storage systems
  - Shared storage for scratch data and permanent simulation data

If the job fails, restart from the preparation step

Preparation
- meshing and preparing job scripts
- requires large local infra for large case

Transfer inputs
- login to HPC and upload input files
- text-based and requires high speed network

Job submission
- jobs are queued until resources are available
- longer waiting time on limited resources

Job execution
- when resources are available, jobs are executed
- monitoring is performed text-based

Post processing
- download results to local workstation with long transfer time
- limited visualization nodes

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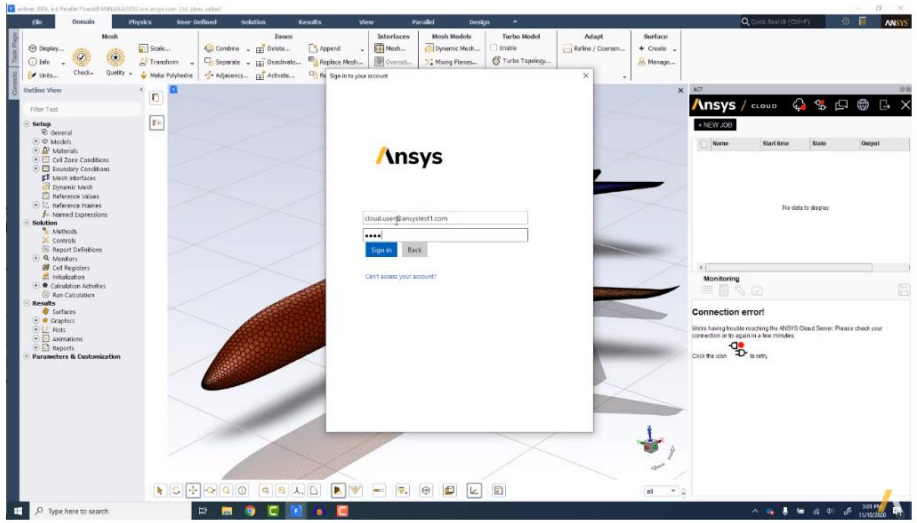
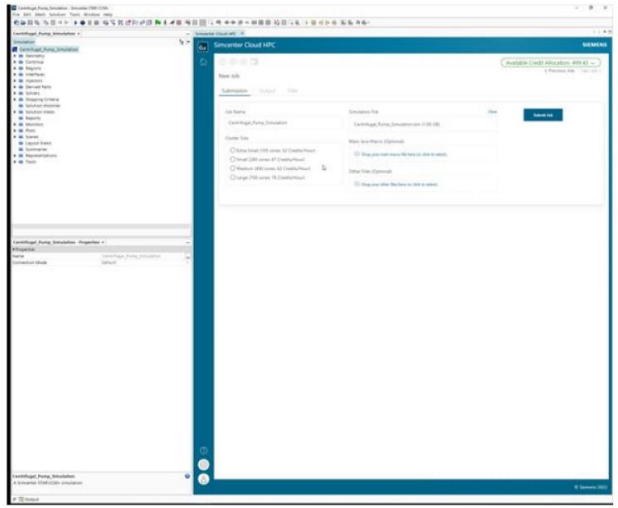
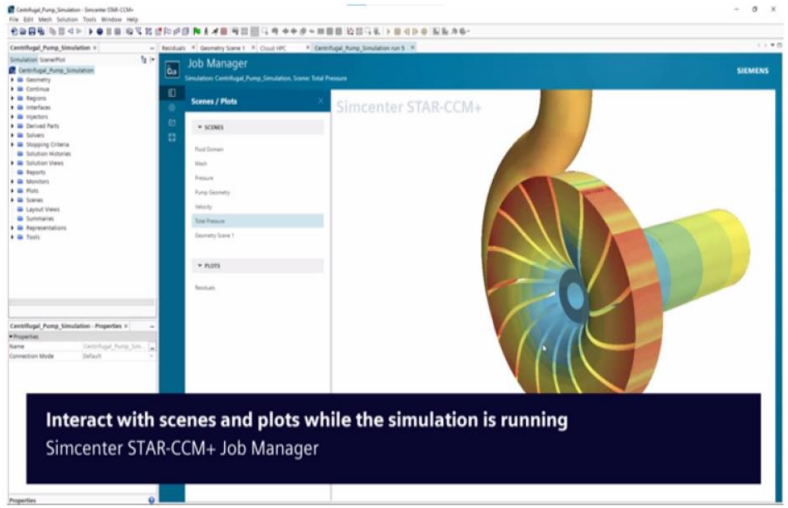
Challenges in HPC: Adapting to Evolving Simulation workflows

- **GUI-based interactive simulation workflows**
  - Enhancement of desktop and workstation performance drives the interactive simulation workflows
- **Growing demand for seamless integration of IT-based environments, including HPC cloud**
  - Ansys Cloud on Azure / Siemens Simcenter Cloud HPC
    - Run pre- and post-processing on the local desktop and simulations on the cloud HPC environment



Ansys Cloud on Azure





Siemens Simcenter Cloud HPC

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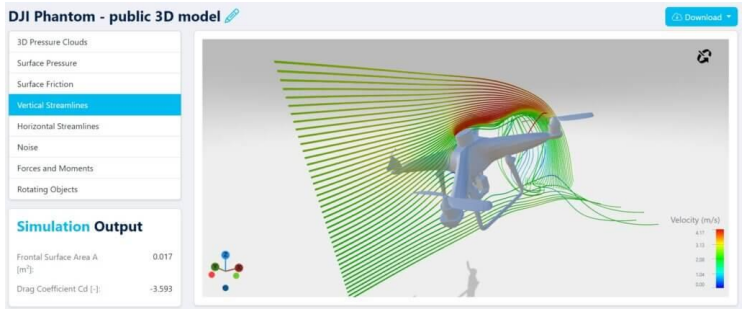
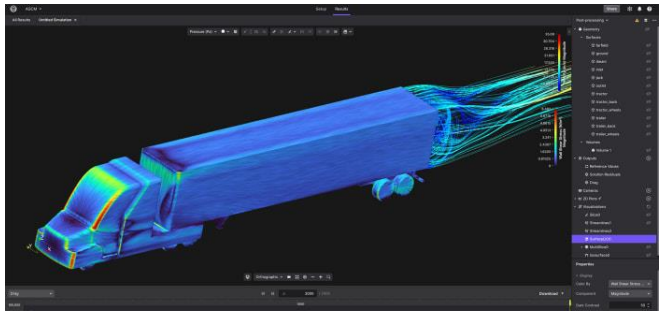
Challenges in HPC: Adapting to Evolving Simulation Workflows

- **Advancement of web-based simulation SaaS services**
  - Upload the simulation geometry and conditions to the service, and the entire simulation is performed in the cloud

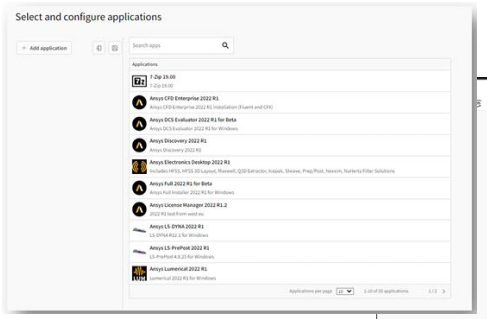


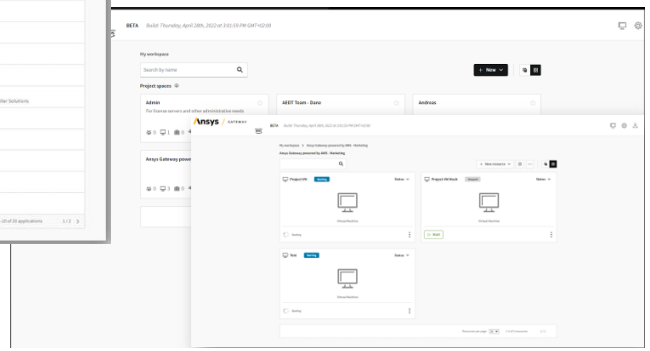
airshaper.com



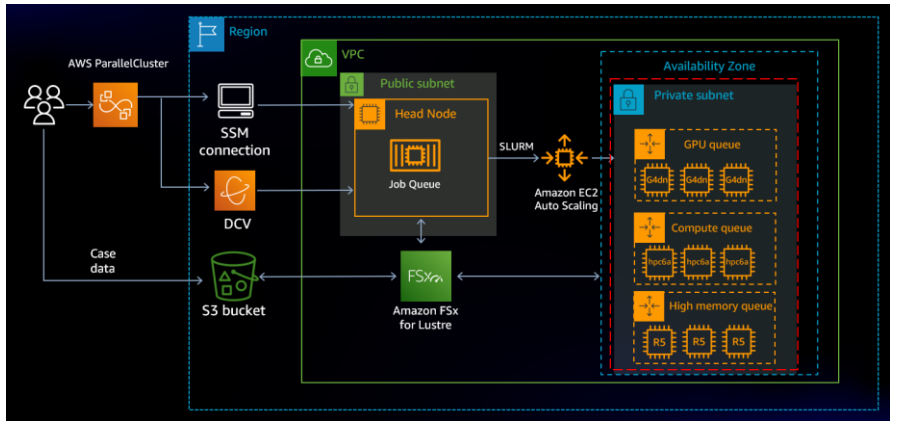
luminarycloud.com

- **Cloud based HPC services**
  - Provide HPC clusters with pre-installed software and perform simulations via a scheduler like traditional HPC in the cloud





Ansys Gateway powered by AWS



AWS ParallelCluster

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Next Generation HPC for CAE simulation

- **Limitations of traditional and current newly introduced HPC architecture**

HPC architectures	Features and limitations
On-premise HPC	• Long setup time, management overhead and inflexible response to simulation workload and long job queueing • Non-interactive simulation based on batch job scheduler and Frequent data transfer for pre and post processing
Cloud integration of application	• Seamless integration of interactive applications • Dependency on specific applications and Cloud services, Lack of support for various simulation applications
Web-based simulation SaaS	• Limited to provided simulation workflows • Challenges in addressing diverse analysis problems
Cloud based HPC service	• Flexible setup and load response, but non-interactive workflow based on batch processing similar to on-premise HPC • Limited to the workflows and software provided by the service provider

- **Future directions of Next Generation HPC**

Directions	Features
flexibility and scalability	• flexible response to varying simulation workloads, reducing job queue times and improving overall efficiency
Interactive workflow	• Support more interactive simulation environments, allowing for real-time adjustments and analysis
Minimize data transfer	• Streamline data transfer processes for pre, post-processing to minimize delays and improve workflow efficiency
Application support	• Expand support for a wider range of simulation applications to accommodate diverse user needs and workflows
Security and Control	• Maintain high levels of data security and control while leveraging the benefits of cloud-based HPC solutions

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NEXTFOAM NextHPC on Azure

- **Flexibility and scalability**
  - Microsoft Azure HPC virtual machines can scale to thousands of cores to meet various workload demands, with InfiniBand network support for high-performance, low-latency communication.
- **Interactive workflow**
  - Start dedicated HPC clusters using a GUI program without manual configuration as needed
  - Connect to the head node using Remote Desktop and perform simulations from pre-processing to post-processing
- **Minimize data transfer**
  - Input and result files are stored in each user's blob storage and shared to group blob storage
- **Broader application support**
  - Use virtual machine images with pre-installed simulation software available in the Azure marketplace.
  - Install your own applications on each HPC cluster as needed.
- **Security and control HPC**
  - Data security and controls of HPC are preserved based on Azure RBAC (Role-Based Access Control)

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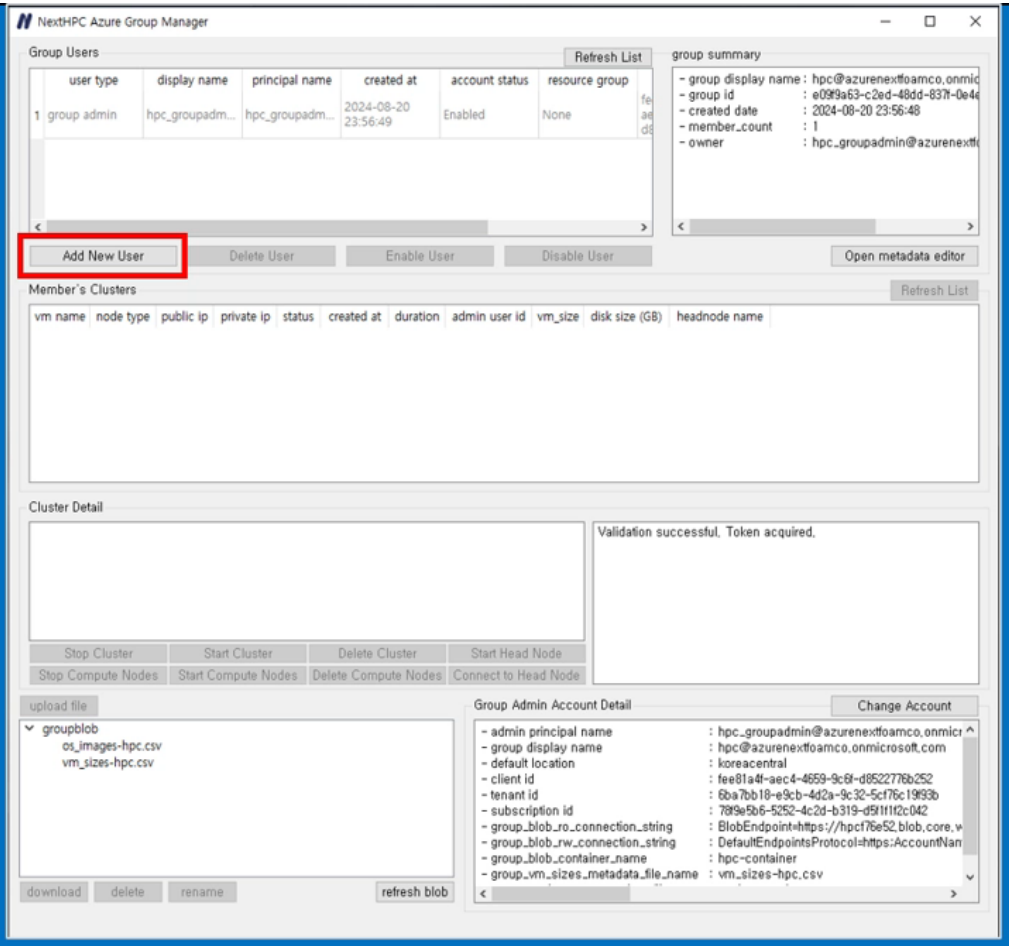
- **Launch HPC cluster using GUI and perform interactive simulation**



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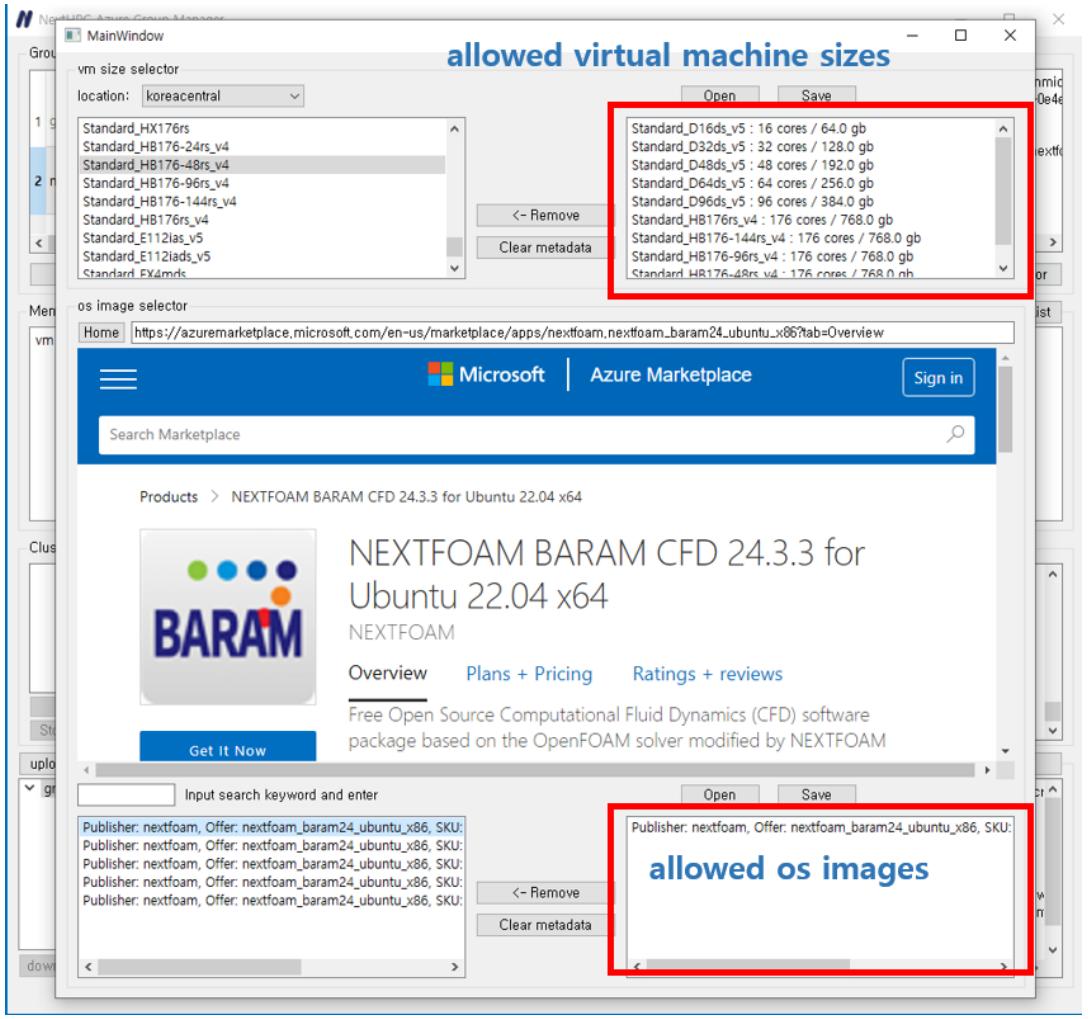
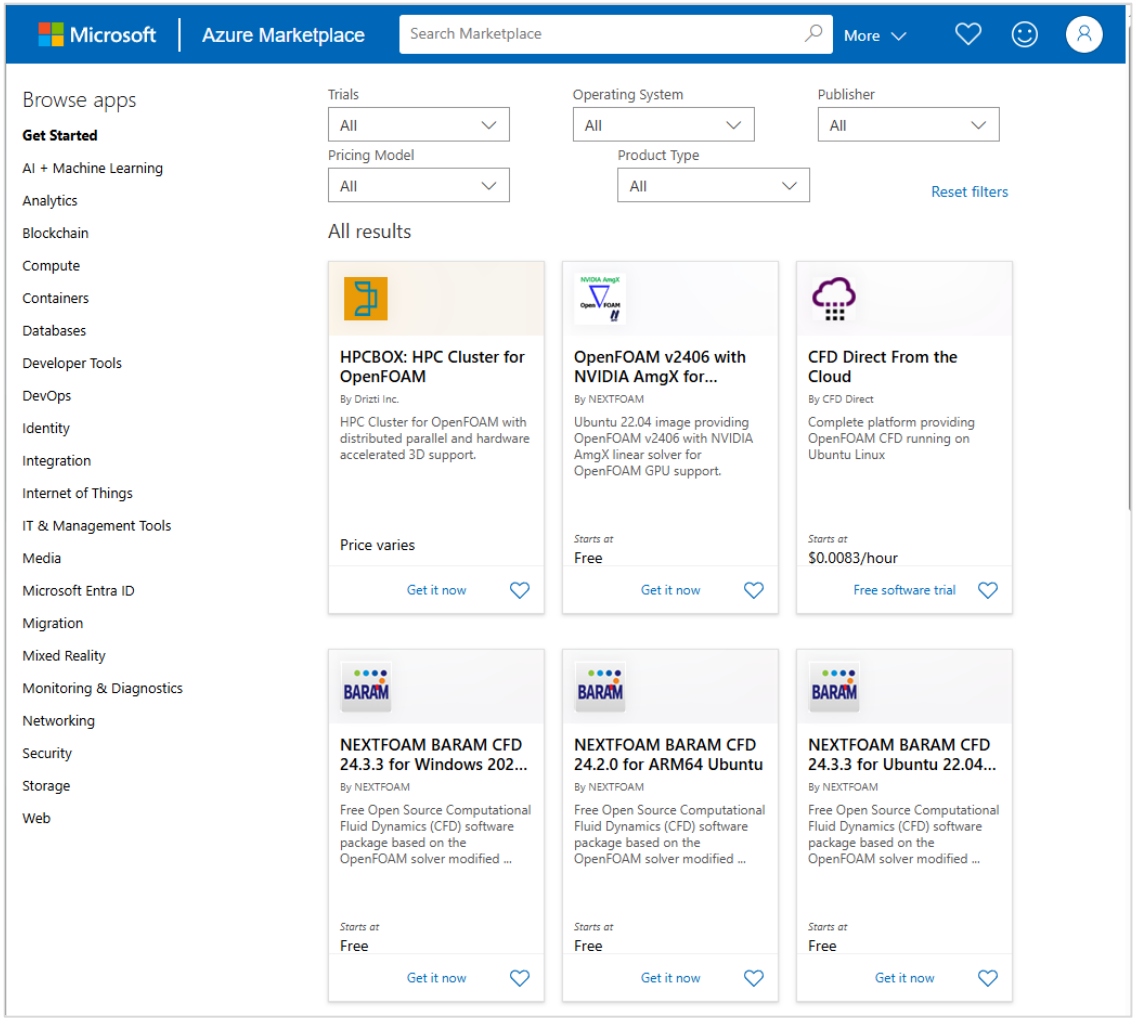
- **Broader application support with Azure Marketplace images**





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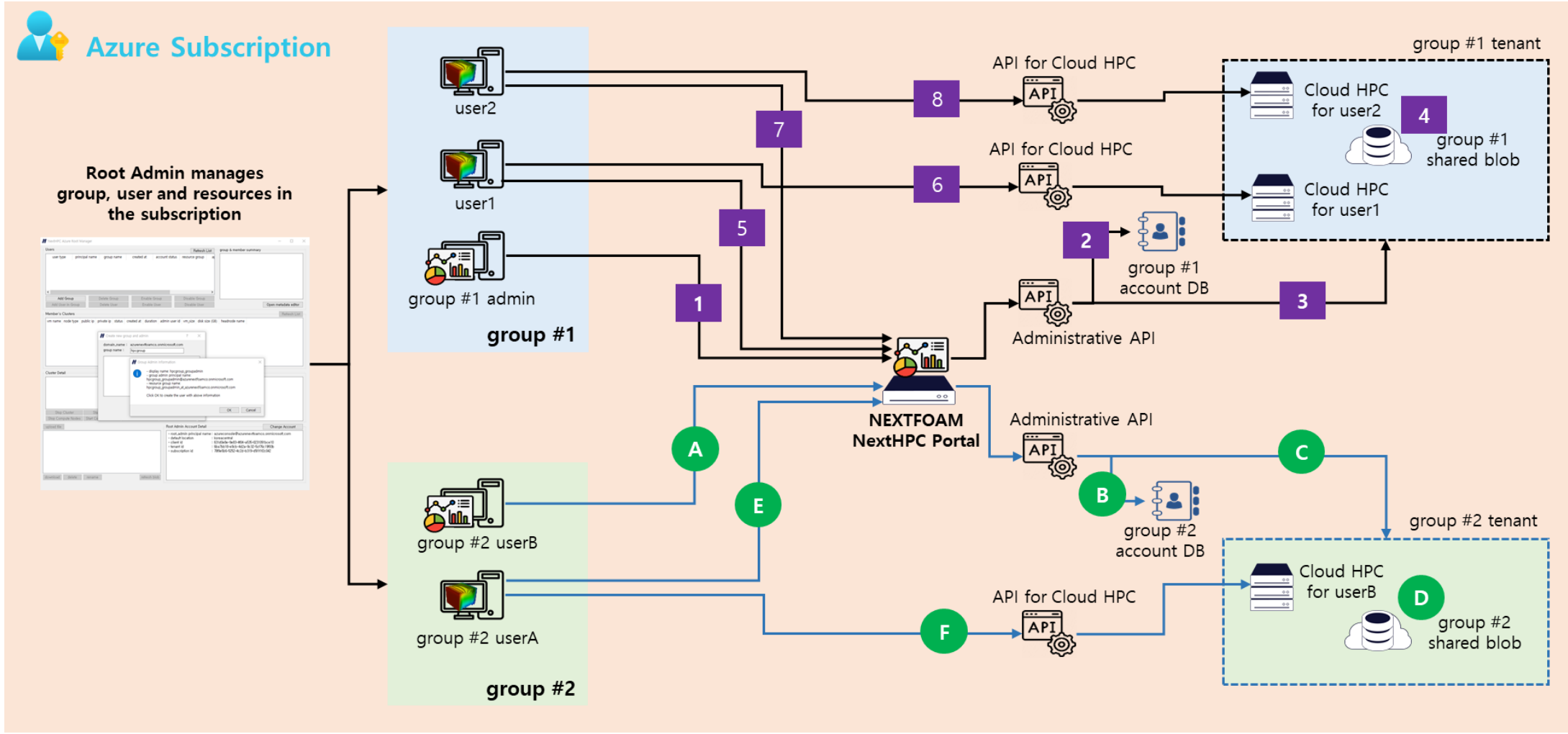
NEXTFOAM NextHPC on Azure

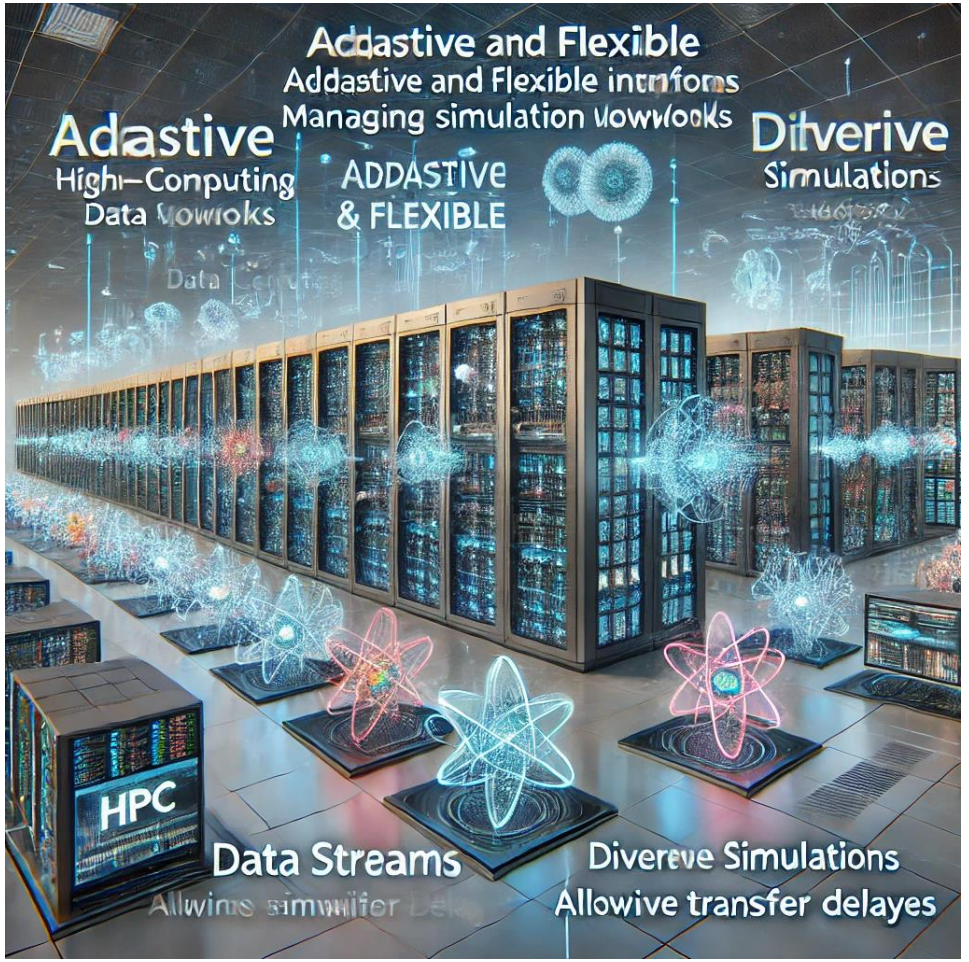
- **Azure RBAC based data security and controls of HPC**



Concluding remarks

- **Need for HPC in CAE Simulation**
  - Handles complex simulations with large data sets efficiently
  - Speeds up computations, enabling faster design decisions
  - Enhances accuracy through detailed and precise simulations
  - Adapts to varying project demands, from small to extensive analyses
  - Scales to meet growing computational needs

- **Future Direction of Next Generation HPC**
  - Offers flexible responses to varying simulation workloads
  - Supports interactive workflows for real-time adjustments
  - Minimizes data transfer delays for improved efficiency
  - Expands support for a wider range of simulation applications
  - Maintains high levels of security and control in cloud environments



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